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# Usingvegetation indices for the estimation and production ofvegetation cover maps inthe Jeffara Plain, Libya

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***Abstract**: Remote sensing data providesan important source for monitoring and mapping vegetation cover. Vegetation Indices (VI) are derived from multispectral satellite datafor use in monitoring vegetation distribution. This paper assesses the potential of SAVI (Soil-Adjusted Vegetation Index) and NDVI (Normalized Difference Vegetation Index), and uses these to demonstrate the production of plant coverpercentage maps in the Jeffara Plain, Libya,using spatial resolution remote sensing imagery in this semi-arid and arid region. A study region in the Jeffara Plain of 13,800ha was selected to permit processing of training and evaluation data due to the variety in irrigated agricultural area and natural vegetation cover densities. The area also provides a variety ofclimatic and soil conditions. A Landsat image was obtained on March 15, 2016, having a pixel resolution of 30 m over this area and used to compare both vegetation indices. Once obtained, a radiometric correction was applied to the image to produce reflectance and ground reflectance, mosaic, and subset. This data was thenclassified to produce a reference of vegetation cover. The values of each index were compared to the equivalent proportion of the area covered by vegetation. A virtual field study was undertakenusing Google Earth for accuracy assessment purposes. Results indicated that SAVI is best suited in this region, with SAVI resultsproviding an $R^2$ of 0.88, whereas NDVIprovided an $R^2$ of 0.86.Overall, SAVI is considered more appropriatefor use in this semi-arid area even though it requires atmospheric correction. The plant coverpercentagemap for the Jeffara Plain was obtained by determining the threshold values of the plant cover percentage using the SAVI index, validated using avisual assessment method based on the use of high resolution images (Digital Globe) from Google Earth.*

***Keywords**: NDVI, SAVI, vegetation indices, plant cover,Landsat, Jeffara Plain,Google Earth*

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## I. Introduction

Vegetation in Libya is characterized by sparse distribution and is usually described as ‘steppe’ as in other arid and semi-arid lands. Vegetation cover in the coastal plains such as the Jeffara Plain consists mainly of annual grasses and other herbaceous vegetation, especially in years with a high rainfall (El-Tantawi, 2005). Libya has a small number of plant species, with most of the variation found in Al-Jabal al-Alkhdar. Overall, there are a few species across Libya. (Hegazy et al., 2011). The main agricultural products in the Jeffara Plain are barley, wheat and maize as cereal crops; olives, plums, oranges and almonds as fruits, and some vegetables. The cereal crops are the most important agriculture products in the public projects and in the small farms of the private sector.

Remote sensing data offers an important source for monitoring and mapping vegetation cover (Xiao and Moody, 2005; Ait Belaid, 2010). Vegetation indices (VIs) are used in remote sensing to estimate the amount of vegetation (Camacho-De Coca et al., 2004; Thiam and Eastman 2001). Monitoring and assessment vegetation covervia the vegetation indices is one of the commonapplications of remote sensing. Vegetation indices are often calculated from the reflectance values in the red (R) and near infrared (NIR) wavebands. There are several Vegetation Indices which have been developed to monitor the vegetation distribution, among of these indices Normalized Difference Vegetation Index (NDVI) and Soil-Adjusted Vegetation Index (SAVI) (Tucker,1979;Huete, 1988 ). NDVI is a commonly used vegetation index inregional and continental scale monitoring of vegetation cover (Foran and Pearce 1990; Wang et al. 2004; Wessels et al. 2004).NDVI hasa high correlation at local scale with various plant parameters, such as leaf area index (Curran et al., 1983), Chlorophyll content (Chappelle et al., 1992), and crop condition (Wiegand et al., 1992).However, NDVI does have limitations where the density of vegetation cover is low to medium. However, many agencies still prefer NDVI as it is straightforward to use. SAVI seeks to minimize soil influence on vegetation quantification through the introduction of a soil adjustment factor (L). For high vegetation cover, the value of L is 0.0 (or 0.25), and for low vegetation cover 1.0. For intermediate vegetation cover L = 0.5, and this value is the one used most widely (Huete, 1988). Masoud and Koike (2006) used SAVI index to produce the vegetation cover map to reduce the influence of soil byconsidered the soil adjustment factor 0.5. Almutairi et al. (2013) note the SAVI index to be recommended for the production of vegetation maps for arid and semi-arid zones, and it is reliable even for historical remote sensing data with the medium spatial resolution from early Landsat scenes.

## II. STUDY AREA

The study area located in North West of Libya covers the Jeffara Plain. The Plain is around (1.958.000) ha(Fig1). The Jeffara Plain is bordered by the Mediterranean Sea to the north, the Tunisian border to the west, and the NaffusahMountain border to the south and east. The climate of Jeffara Plain has typical Mediterranean and semi-arid conditions, rain in winter with a hot, dry period in summer, the total annual rainfall ranging between 140- 550 mm, with a mean annual temperature of between 14.2 C° to 21.0 C° at coastal stations and a mean annual relative humidity of about 70% (Ageena, 2013).

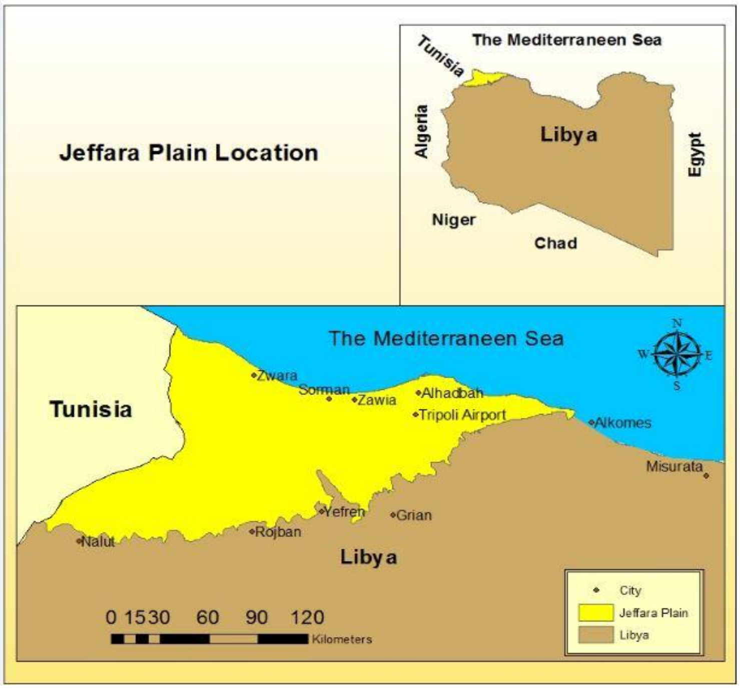


**Figure (1)** The Jeffara Plain study area

## III. METHODOLOGY

To produce plant cover percentage maps of the study area, remote sensing data of Landsat ETM satellite images covering the Jeffara plain were collected for year 2016. To assess the potential use of NDVI and SAVI to determine and identify the threshold values of plant cover percentage in the Jeffara Plain,the followingstepswere undertaken:

(i) An initialcomparison between NDVI and SAVI indices was undertaken to determine which index is best for use in the study area. Figure (2) shows the methodology of the comparison between NDVI and SAVI indices.

(ii) Pre-processing of remote sensing data was undertaken, and radiometric correction was conducted to convert digital numbers into (T0A) reflectance and ground reflectance so as to obtain the ground reflectance for the images, undertaken using ENVI software (Exelis Visual Information Solutions, 2017). BothNDVI andSAVI indices use spectral bands in the red and near-infrared portion of the electromagnetic spectrum, the near-infrared is the reflectance value of this band, and red is reflectance of the red band. ENVI software was used to compute the NDVI by using Equation 1 and SAVI by using Equation 2.

Equation 1 $NDVI= (NIR-RED)/ (NIR+RED)$

Equation 2 $SAVI= ((NIR-RED)/ (NIR+RED+L))*(1+L)$

Where: NIR = Near Infra-Red Band (Band 5 in Landsat 8).

RED = Red Band (Band 4 in Landsat 8) L = soil adjustment factor.

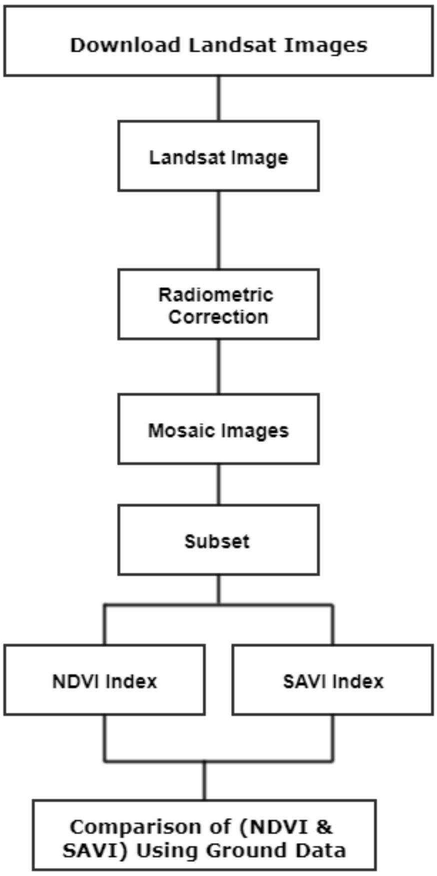


**Figure (2)** Methodology adopted for the comparison ofNDVI and SAVI indices

To produce plant cover percentage map, it is necessary todetermine the threshold values of the plant cover percentage classes by use the ground truth data. Figure (3) shows the methodology used in the production of thismap.

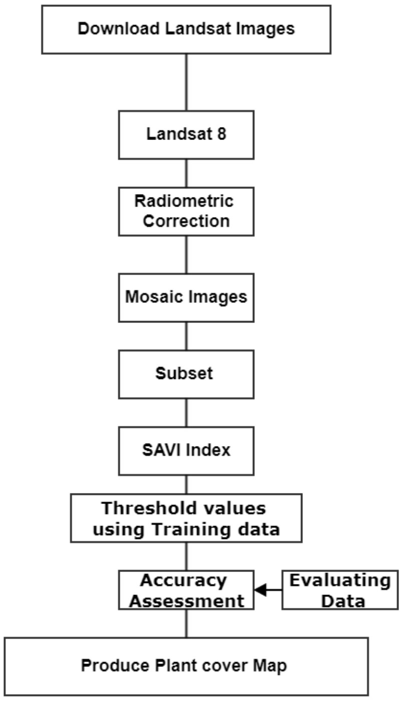


**Figure (3)** Methodology used to produce plant cover percentage map

Due to the lack of existing ground truth data, and prohibitively high costs of conducting new studies, as well as security issues, a visual assessment method was used to generate ground data for plant cover percentageby using the high resolution images (Digital Globe), made availableinGoogle Earth. An area in the Jeffara Plain of about 13,800 hectares was selected to process the ground truth data due to the variety of vegetation cover densities, climate,and soil types: Figure (4) shows the selected area. The number of samples was determined to be representative of the ten main soil types present in the selected area. The practical minimum samples which are recommended by Swain and Davis (1978) is N*10 where (N) represents the soil types. Based on this equation, the number of random samples for training and evaluating data was created in the selected area using the fishnet tools in the ESRI ArcGIS software.The high-resolution images (Digital Globe) from Google Earth were used to determine the classes ofthe plant cover percentage (< 30%, 30-60% and > 60%) of sample locations. A fishnet was created in ArcGIS software (Esri, 2015), dividedinto 30 metre cells for each sample, fitting with the Landsat pixels. This was then further subdivided to 5 metres to allow easy identification of the percentage of the land cover (< 30%, 30-60% and > 60%) using a visual assessment method to obtain the ground data (Training and evaluated data).

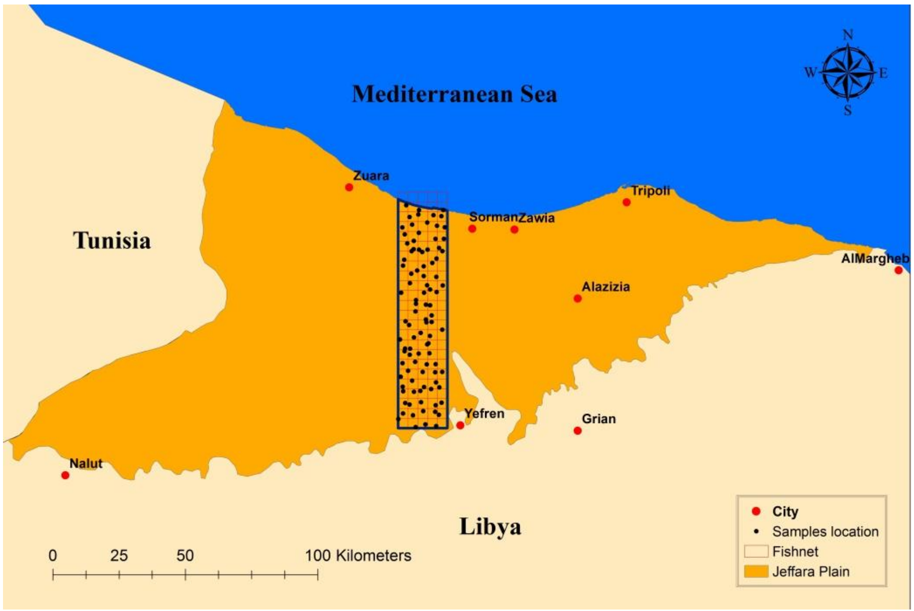


Figure (4) A selection of the study area showing variety of vegetation cover, climate and soil

## IV. Results

### Comparison between NDVI and SAVI indices

The values for the indices were compared to the ground data equivalent proportion of the area covered by vegetation to determine acorrelation between the indices, Figure 5.

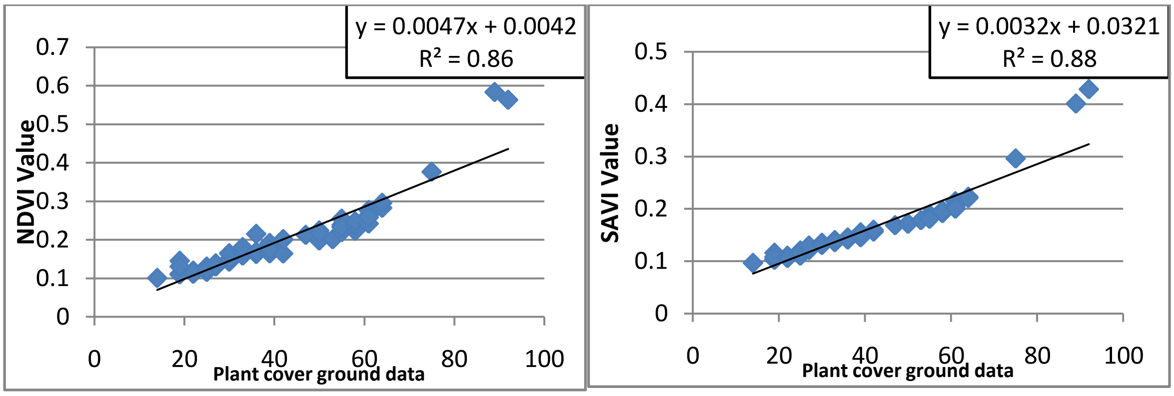


**Figure (5)** noitalerroC (5)between NDVI and SAVI Indices with plant ground cover

The results indicate that SAVI to has aslightly bettercorrelation when compared to the NDVI index, with $R^2$= 0.88 for the SAVI index whereas the NDVI index has $R^2$= 0.86. However, the SAVI index was adopted for the production of vegetation mapin order to reduce the effects of the soil background (Huete, 1988; Masoud and Koike 2006).

**The production avegetation cover percentagemap**

The plant cover percentage of the study area was divided into three classes (> 60 %, 60 - 30 % and < 30 %). The SAVI index was applied to determine the threshold values of the vegetation plant cover percentageclasses and to produce the vegetation plant cover map for year 2016. The threshold values of the SAVI were obtained by using ground data (training data).The threshold values of vegetation cover percentage classes (< 30%, 30 - 60%, and > 60) are ranged from (0 - 0.13, 0.13 - 0.2, and > 0.2) of SAVI respectively. Thenthe threshold values were assessed by using independent data (Evaluating Data). Aconfusion matrix was used to assess the accuracyof vegetation plant cover percentage. The overall accuracywas found to be 94 %, see Table 1. The user's accuracies for all classes which represent the individual classes were high, ranging from 90 % to 98 % for plant cover percentage; this result was considered acceptable,being above the 70% value suggested byLillesand et al. (2005).

**Table** 1 Confusion matrix for the classified image of plant cover

| | | Reference Data (Evaluating Data) | | | | |
|---|---|---|---|---|---|---|
| | | Class Name | < 30 % | 30-60 % | > 60 % | User's accuracy (%) |
| SAVI Index Classified Data | Plant cover | <30 % | 45 | 5 | 0 | 90 % |
| | | 30-60 % | 1 | 53 | 0 | 98 % |
| | | > 60 % | 0 | 1 | 10 | 91 % |
| | | Producer's accuracy (%) | 98 % | 90 % | 100 % | Overall Accuracy = 94 % |

The2016 plant cover percentage map of Jeffara Plain, produced using the threshold values created from SAVI image, is shown in Figure 6. A large part of the study area falls within the < 30% percentage cover (54%), about 1.057.370 ha. About 31.1% (608.968 ha) of the area is classified as 30 - 60% percentage cover with small percentages of the > 60%percentage cover class (291.756 ha).

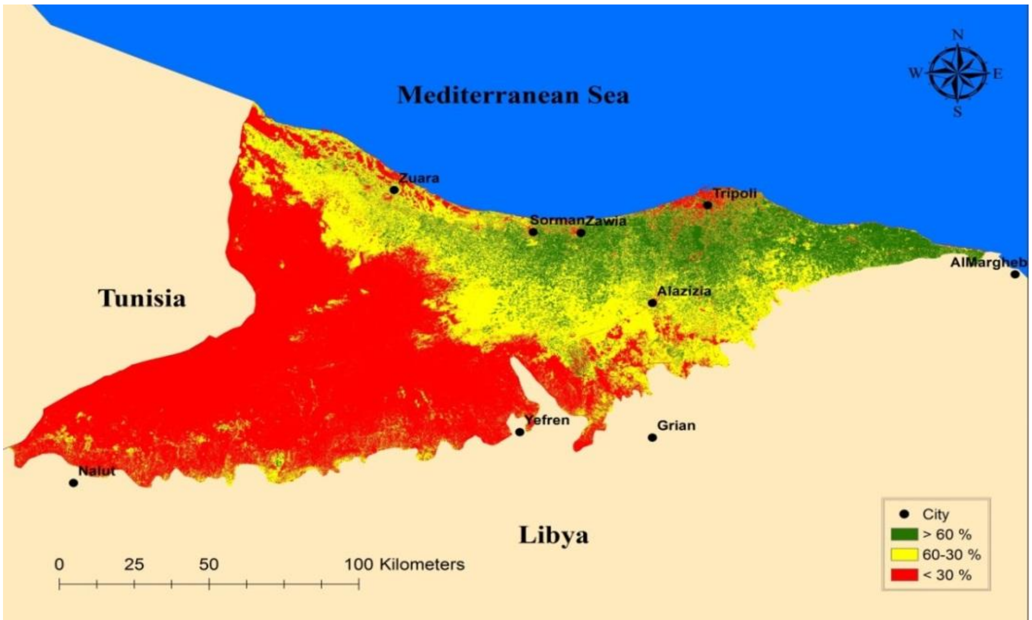


**Figure (6)** Plant Cover percentage acrossthe Jeffara Plain, 2016

## V. Conclusion

The comparison between NDVI and SAVI indices showed that the SAVI is best suited for use in the Jeffara Plain. The results indicate the SAVI has stronger correlation when compared to the NDVI index. The SAVI result gave an $R^2$ of 0.88 whereas NDVI gave an $R^2$ of 0.86. Hence SAVI is better to use in this semi-aridarea because SAVI take account the influence of the soil. Even though it requires an atmospheric correction itstill producesbetter results compared to NDVI.

The use of Google Earth imagery, together with Vegetation Indices (VI) such as SAVI, derived from satellite imagery can be used to providea useful source for monitoring and mapping vegetation cover. The Jeffara Plain has been divided to three classes of plant cover percentage. The results demonstrate that most of the Jeffara Plain has vegetation cover less than (30 % ) about 54 %, whereas the high vegetation cover more than (60 %) represent only 14.9 % of the Plain.

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